ARI Research Note 97-21

Problem Solving of Mid-Career Army Officers: Identification of General and Specific Strategies

Julia Pounds
Human Resources Research Organization

Jon J. Fallesen
U.S. Army Research Institute

Fort Leavenworth Research Unit
Stanley M. Halpin, Chief

August 1997

United States Army
Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Director

Research accomplished under contract
for the Department of the Army

Human Resources Research Organization

Technical review by

Rex R. Michel

REPORT DOCUMENTATION PAGE

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
1997, August	Interim	June 1996-July 1997

4. TITLE AND SUBTITLE	5a. CONTRACT OR GRANT NUMBER
Problem Solving of Mid-Career Army Officers: Identification of General and Specific Strategies	MDA 903-93-D-0032
	5b. PROGRAM ELEMENT NUMBER 0603007A
6. AUTHOR(S)	5c. PROJECT NUMBER A792
Julia Pounds (HumRRO) and Jon J. Fallesen (ARI)	5d. TASK NUMBER 1122
	5e. WORK UNIT NUMBER C09

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)		8. PERFORMING ORGANIZATION REPORT NUMBER
Human Resources Research Organization 6 Canal Center Plaza, Suite 400 Alexandria, Virginia 22314	U.S. Army Research Institute for the Behavioral and Social Sciences Fort Leavenworth Field Unit Fort Leavenworth, KS 66027-0347	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. MONITOR ACRONYM
U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333-5600	ARI
	11. MONITOR REPORT NUMBER Research Note 97-21

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

COR: Robert E. Solick

14. ABSTRACT *(Maximum 200 words)*: The Army needs a better understanding of how skilled military leaders solve problems in complex battlefield situations. The military has relied on analytic comparison methods and "6-step" models. Recent studies found that these methods do not correspond to complexities of actual tactical situations. Shortcomings of rigid procedures highlight the usefulness of more naturalistic approaches but research has yet to provide detail about using naturalistic strategies. Eighty U.S. Army officers were interviewed and asked to recommend courses of action for tactical scenarios. They discussed their approaches to problems and identified strategies used in their thinking. Results showed that participants used combinations of approaches within problems. Differences in how strategies were used to develop courses of action were compared. One set of strategies was identified as positive or negative indicators for four likely solutions. Results suggest that to effectively train skilled problem solving, approaches and strategies that are actually being used first have to be identified, their advantages and disadvantages characterized, and methods for training them developed. Findings can be used to support training by identifying how thinking leads to solutions and how more and less skilled problem solvers differ in the ways they solve problems.

15. SUBJECT TERMS

Naturalistic decision making Human performance Battle command Leadership Problem solving

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT	17. ABSTRACT	18. THIS PAGE			
Unclassified	Unclassified	Unclassified	Unlimited	35	Jon Fallesen 913-684-4933

PROBLEM SOLVING OF MID-CAREER ARMY OFFICERS: IDENTIFICATION OF GENERAL AND SPECIFIC STRATEGIES

EXECUTIVE SUMMARY

Research Requirement:

The Army needs to have a better understanding of how military leaders solve problems in uncertain battlefield situations. Often these situations are complex, characterized by the familiarity of the problem to the problem solver, the stakes involved in the consequences, time pressure, and the effort that is necessary or available to devote to the problem. Although the military services have largely relied on exhaustive analytic comparisons or "6 step models" for decision making procedures, recent studies found that these methods do not correspond well to the needs of complex tactical situations. Shortcomings of rigid procedures point to the usefulness of approaches that correspond to how people at various skill levels actually solve problems in dynamic situations. However, research has yet to provide details about the utilization of actual naturalistic strategies to develop higher levels of problem solving skills. To effectively train the skilled use of naturalistic strategies, a deeper understanding of tactical problem solving is needed. Strategies (persistent ways of thinking that individuals use to solve problems) first have to be identified, their advantages and disadvantages in various situations characterized, and methods for improving them developed.

Procedure:

Eighty Army officers were interviewed separately about the ways that they approached and solved problems. Participants rated how often they used four approaches: analytic comparisons, 6-step procedures, a recognition process, and a method that favored an option that was initially promising. They talked aloud about what they were thinking while solving two tactical problem scenarios and indicated which strategies were used to reach their proposed solutions. For example, one candidate strategy was *Broke the problem into smaller problems*. They rated the importance of strategies they used and gave examples of how each important strategy was used.

Findings:

Participants used more than one approach to solve the problems. Responses suggested that participants developed solutions by using either a set of prescribed steps or developing a likely candidate option, but not both. Although Army training advocates prescribed step-wise methods, participants' time in service was not related to their preferences for using those methods.

The familiarity of the problem and the effort expended were also related to participants' selection of approaches. When the problem was more familiar (e.g., seizing a river crossing) participants indicated that they relied on recognizing a solution based on their past experience with similar problems. When the problem was less familiar (e.g., a hostage rescue), participants relied either on developing a promising course of action or on a procedure, but not both. Use of an analytic approach was associated with more effort to think about the problem, while the recognition approach was associated with less effort.

Proposed courses of action for the more familiar problem were associated with the use of different strategies. Four courses of action were related to the strategies used: hold back, retake the assembly area, take the assembly area and forward ground, or bypass the original assembly area phase and focus on the second phase (bridge). Strategies were then compared across solutions. Fifteen strategies were identified as indicators of which course of action was proposed. Seven strategies were positive indicators for all four solutions. For example, people who focused on the bridge did not report using the strategy *Used specific and precise comparisons*. People who held back or focused on the assembly area were more likely to report using specific and precise comparisons in their thinking. On the other hand, *Used the solution that had worked most often in the past* was used by those who proposed either the hold back or bypass solutions. This suggests that the use of prior knowledge might have been more of a factor in these solutions than the others involving the assembly area.

Strategy use can also be interpreted based on the results of other research on problem solving in uncertain situations and how prior experience is employed by more and less skilled participants. For example, solutions that included moving forward to the bridge were more likely to be associated with consideration of the relevancy of available information. Based on research of expertise, one would expect that this strategy would be one that would be used by the more experienced problem solvers. Similarly, those who proposed the "hold back" solution and the "take back the assembly area" solution were less likely to report looking for flaws in the plan than those who proposed courses of action that went forward to the bridge.

Utilization of Findings:

A better characterization of naturalistic approaches and strategies for complex tactical scenarios will result from identifying how military leaders approach problems and what strategies they employ to plan a course of action. By developing a fuller characterization of the naturalistic strategies, their advantages can be exploited and their disadvantages can be identified and fixed.

These interim findings illustrate that differences in thinking processes and relationships between strategies and solutions influence course of action planning. Ongoing work to identify differences between strategies used by the less and more skilled problem solvers can be exploited to facilitate training of those with less skill or fewer experiences to employ.

PROBLEM SOLVING OF MID-CAREER ARMY OFFICERS: IDENTIFICATION OF GENERAL AND SPECIFIC STRATEGIES

CONTENTS

List of Tables

List of Figures

PROBLEM SOLVING OF MID-CAREER ARMY OFFICERS: IDENTIFICATION OF GENERAL AND SPECIFIC STRATEGIES

Introduction

Despite great interest, there is much uncertainty about what leads to skilled problem solving and decision making. When a problem solver is faced with the task of making a high quality decision in a complex, variable, ill-defined, and novel real-world problem, the optimal approach and a distinct goal are seldom obvious. Time is often short and the solution frequently has high stakes consequences. Nevertheless, people manage to solve these types of problems, often relying on their prior knowledge.

How people manage this is not usually clear, although different approaches have been identified. "Approach" differs from "strategy" primarily in the level of processing chosen for analysis. Where "strategy" is a regularity in reasoning that guides thinking in a particular situation (Bruner, Goodnow, & Austin, 1956), an "approach" is more an over-arching combination of strategies. Moreover, in real-world settings, separation of problem solving from decision making is somewhat arbitrary (Connolly & Wagner, 1988). Thus, no effort was made here to distinguish problem solving from decision making strategies.

Many problem solvers appear to follow a natural thought process, using their knowledge and experience to understand the situation and to determine what to do (Klein, 1989). Often the situation is recognized as familiar and a past solution implemented. For less familiar situations, workable solutions can be developed by selecting a likely candidate and developing it, by using strategies such as breaking the problem into smaller problems, by changing the problem into a different type of problem, or by employing analogies.

Four approaches have received research attention: analytical, procedural, recognition, and dominance structuring. These four vary primarily in their reliance on different components of the problem solving process to ensure effective solutions. Procedural models emphasize the importance of a sequential framework. Analytic models rely on thorough assessment of information. Recognition models emphasize one's use of prior experience. Dominance models hinge on structuring the process using one's values and sensitivity analysis. Other factors such as time available, importance of the outcome, and the effort required have also been demonstrated to influence strategy use (Payne, Bettman, & Johnson, 1993).

Background

Procedural Approach

Historically, both problem solving and decision making have been described by a step-wise approach. With variations, this is basically a sequential procedure resembling the following: define and reorganize the problem, identify information, list possible solutions, test possible solutions, select and implement the best solution (e.g., Bransford & Stein, 1993; Janis & Mann, 1977; Miller, Galanter, & Pribram, 1960; Newell & Simon, 1972).

The benefit of this approach is that it provides a set of subtasks that can be applied to solve a variety of problems. Educators often develop an unfounded belief in the inherent capability of the process itself to identify a solution and that skillful use of these steps is obvious to the problem solver. However, the procedure gives little guidance as to how additional information might modify or eliminate

the steps, or how they can be supplemented. Likewise, "[t]he learner who memorized only a series of steps will be less likely to know what knowledge he or she possesses might be useful" (Catrambone, 1995, p. 34). This would be an obstacle to solving a problem which the problem solver has not encountered before.

Analytical Approaches

A number of prescriptive models have been developed as techniques to aid in solution selection (Anderson, Deane, Hammond, & McClelland, 1981). These analytical methods dictate a sequential procedure to identify the option with the highest utility value: define the problem, identify the set of options, eliminate unreasonable alternatives, list all comparable attributes, assign utility and weight values to each attribute, calculate the total for each alternative across its attributes. Utility is often defined as monetary value and weight as importance. The alternative with the highest total utility value is chosen.

These techniques provide an internally consistent logical system to organize the information about possible options and their attributes so that an optimal solution can be identified and selected. The quality of the outcome depends on accurate knowledge of all options, criteria, and values. However, these approaches have become the basis for much decision aiding technology by showing people how to make their decisions conform to the technique.

Getzels & Csikszentmihalyi (1976, pg. 248) note that "A person who claims his ... problem ultimately [is] solved so that it cannot be altered any more--must believe that he has found the correct solution; but correct solutions exist only for problems that have already been solved before." In complex, dynamic, ill-defined problems that are novel to the problem solver, the indisputable correctness of solution is not singularly important. Rather, what is important is how workable the solution is up front and how successful it was after the fact. Beach and Lipshitz (1993) point out that analytical models are based on a theory that "is an abstract system of propositions that is designed to describe the choices of an ideal hypothetical decision maker--omniscient, computationally omnipotent Economic Man (p. 21)." Thus, in real-world, ill-defined, dynamic situations where all the information is not known nor knowable and when time is not available, these models lose their usefulness. For example, Payne et al. (1993) found that performance of decision makers was sensitive to time pressure and the requirement for effort or accuracy.

Dominance

In contrast, Montgomery (1989) proposed that a person defines the relevant dimensions of the problem, and identifies a promising alternative by eliminating any alternatives that are unattractive on important attributes. An alternative is then immediately chosen if it is better than all other options on at least one dimension and equal to the other options on all the other dimensions, or on some absolute criteria. However, if the promising alternative does not initially dominate all others, the advantages and disadvantages are reconsidered relative to the other candidates. Mental operations restructure the information about alternatives until one candidate seems best from every perspective--in essence a qualitative sensitivity analysis. If the promising candidate then dominates the other alternatives, it is chosen. Otherwise, the entire process is repeated by selecting another promising candidate or the relevant information is reexamined to see if the favored alternative can become dominant.

This description and its variations (e.g., Beach, 1990) is consistent with how people appear to make some choices, particularly when heuristics are used to guide the process. Moreover, the promising alternative is often picked out early in the process. However, personal values play an important heuristic

role in structuring the process, which can lead to selective perceptions. The quality of the process depends on the early phases for selection of the attributes that are relevant to the problem. Thus the decision maker's values about what is important influences solution effectiveness.

Recognition

Research has demonstrated that problem solvers rely on prior experience to find a workable solution. The first option considered is often an acceptable solution which can then be evaluated and developed (Klein, 1989).

The effectiveness of the solution largely depends on the problem solver's level of experience in the domain. Early recognition of an effective candidate is a process that has also been associated with expert problem solving. This approach is often used when time pressure exists, when the situation is ambiguous and unstable. Further, this approach is often used when the information is acquired perceptually (that is, the information does not require synthesis and analysis much beyond initial perception), when information is continuous rather than discrete, and when information is simultaneously displayed to the problem solver (that is, multiple cues are experienced at the same time) (Hammond, 1993).

Approaches Compared

In sum, a variety of ways have been proposed to describe and prescribe human problem solving and decision making. The four characterized here vary primarily in their reliance on different components of the problem solving process to ensure effective solutions. Procedural models emphasize the importance of a sequential framework. Analytic models rely on thorough assessment of information. Dominance models hinge on structuring the process using one's values. Recognition models emphasize use of prior experience.

Both analytic and procedural approaches are prescriptive in that they emphasize that the best solution will result when the problem solver follows a particular process of making decisions and solving problems. Both these methods advocate that the problem solver define a set of candidate solutions which are then compared. When a procedural or analytic method is used, the use itself is often taken as proof that the resulting choice is the optimal alternative. On the other hand, recognition and dominance approaches propose that the problem solver select a good option to develop.

Moreover, the success of all four approaches depends on one's prior knowledge about the situation. Although Klein (1993) acknowledges that both analytic and recognition-based approaches can be useful, it is not clear how prior knowledge, one's approach to the problem, and strategy use interact to enable the solution of dynamic and non-routine problems. Both recognition and dominance are descriptive models of how some people have solved problems. However, they provide little guidance about how to do it better. Moreover, if analytic and procedural approaches are not sufficient in uncertain, dynamic situations and if recognition cannot be applied, then what approach is employed when the stakes are high and there is not time for detailed analysis?

A more robust representation takes the perspective that one method does not fit all problem situations. Rather, problem solvers approach problems in different ways and have a variety of candidate strategies available that can be tailored to the needs of the specific problem (Payne et al., 1988; Pounds & Fallesen, 1994). In this view, many factors would influence the tailoring process such as personal experiences, domain knowledge, type of problem, problem context, and personal preferences.

Effectiveness of outcomes can also be influenced by the problem solver's experience in the problem domain, task factors (such as amount of information available), and situational factors (such as time available and consequences of the outcome).

Research Questions

From an overview of problem solving and decision making literatures, four research questions were identified (Pounds & Fallesen, 1994).

1. How do military leaders approach tactical problems?
2. What factors influence approach use (e.g., type of problem, situational factors)?
3. What strategies are used?
4. Is strategy use related to the solution that is selected?

Question #1: How Do Military Leaders Approach Tactical Problems?

Skilled problem solving is highly valued for military tactical planning and conduct of battle (Fallesen, 1993; Halpin, 1995; Rumsey, 1995). The military services have largely relied on methods that call for objective, exhaustive, and systematic comparison of options. The model taught during Army officers' instruction in tactical planning suggests that an analytical approach is best: generate multiple alternatives, assess each independently, and then compare them, selecting the "best" course of action. However, a review of tactical problem solving findings discovered that commanders did not closely conform to these procedures (Fallesen, 1993).

Although a variety of techniques to promote "rational" choice have been based on prescriptive utility models, these techniques are often too rigid and time consuming to be appropriate for finding solutions in complex, changing environments. Simplistic procedural models or exhaustive comparisons are not appropriate or sufficient for the complexities of actual situations (Fallesen, 1993). Prescriptive decision analytic models were found to be limited, particularly when planning in situations of uncertainty (Fallesen, 1993; Fallesen, Carter, Perkins, Michel, Flanagan, & McKeown, 1992).

In a comprehensive review of research on the Army planning process, Fallesen (1993) found evidence that actual problem solving was disconnected from prescribed processes. Effective solutions depended on the quality rather than frequency of procedures. Goals, constraints, and situation knowledge rather than systematic methods governed option selection. These findings suggest that instruction should include these factors. Just what would constitute this alternate instruction has yet to be identified. However, a promising course of Practical Thinking instruction has been developed and tested (Fallesen, Michel, Lussier, & Pounds, 1996).

By examining how military leaders actually approach tactical problems and by identifying the strategies that they use to reach a workable solution, the question of what a more relevant training method might look like can begin to be answered. From this, strengths and likely error points in the strategies used can be identified and appropriate instructional support designed.

Question #2: What Factors Influence Approach Use?

Individual, situational, and task characteristics have been shown to influence how people approach problems. Although people generally demonstrate limited capacities for processing information

about their environment, research has demonstrated that people can adapt to task demands and characteristics of decision situations.

When situations have multiple, conflicting goals, people have demonstrated the flexibility to make trade-offs between accuracy and effort (Payne, Bettman, & Johnson, 1993). In situations where time pressure exists, people have demonstrated that they spend less time thinking about the problem. One can speculate that this is due to "thinking faster" while still considering all the options, evaluating them on all important attributes, and selecting the one with the highest resulting value. This argument assumes that decision makers are still using analytic methods (Orasanu & Connolly, 1993). However, rather than "thinking faster," skilled problem solvers appear to focus on the type of problem, applying their prior knowledge about similar situations to the problem at hand by recognizing the situation as a previously solved problem or by developing a promising alternative, by selecting only the most relevant information to think about, considering only a few options, or changing strategies. Moreover, performance in time pressured decisions has been demonstrated to improve with experience in the problem domain (Klein, Calderwood, & Clinton-Cirrocco, 1986; Payne et al., 1993).

In addition to accuracy, effort, and prior knowledge, the perceived severity of the consequences of the outcome also influences problem solving. Higher stakes increase indecision and the tendency to persist with the first decision once it is made (Lipshitz, 1993). Tactical problems generally occur in these types of time pressured, high stakes situations.

Question #3: What Strategies Are Used?

Judgment and decision making literatures abound with proposed strategies to solve problems (see Pounds & Fallesen, 1994). Because strategies for organizing information are an inherent part of our thinking, they have been studied in a variety of domains. However, strategies can facilitate or hinder the problem solving process. Facilitation occurs by knowing how, when, and where to apply one's knowledge using an appropriate strategy. Problem solving is hindered when knowledge is misapplied or when an inappropriate strategy is applied.

Payne et al. (1993) reviewed studies which found that strategy selection was partially contingent on attributes of the problem. In the presence of a large set of information, people might selectively attend to only the relevant information; however, it has also been demonstrated that irrelevant information can influence the process (Gaeth & Shanteau, 1984). The amount of information can also influence the use of trade-offs. As task complexity increases, people tend to rely on simpler strategies.

Although strategy use has been associated with approach, little work has been done to identify which strategies are unique to a particular approach. For example, identification of relevant aspects is associated with the use of a recognition approach. However, relevant aspects may also be part of the successful use of the dominance approach. Another example would be the strategy of relying on quantitative assessments. Both analytic and dominance approaches incorporate this strategy, but in varying degrees. Thus, rather than one set of strategies comprising one approach, it is more likely the case that the same strategy is incorporated into different approaches.

Question #4: Is Strategy Use Related to the Solution That is Selected?

In other words, does it matter which strategy is used? A "process" perspective proposes that the strategies which the problem solver employs to reach a solution should be the main focus (Ford, Schmitt, Schechtman, Hults, & Doherty, 1989). This perspective emphasizes the importance of information

acquisition and analysis, and the importance of minimizing error points in the process to arrive at a better decision. An "outcome" perspective, on the other hand, focuses on the decision irrespective of how one gets there.

Process and outcome perspectives need not be mutually exclusive, however. Focus on how differences in process relate to differences in outcomes would illustrate how one's strategy influences one's decision. Different strategies may be associated with different solutions.

Research using skilled problem solvers has demonstrated that they use different strategies to reach solutions than do the less skilled (Klein et al., 1986). Further, skilled problem solvers make better quality decisions, often by tolerating small errors in order to avoid making large errors. Specific differences in strategy usage between more and less skilled problem solvers could be explicitly included in training programs as domain knowledge increases, rather than just hoping that the more effective strategies will emerge spontaneously.

Purpose

The purpose of this research was to examine how military leaders go about solving tactical problems and to identify the strategies they used to reach a solution. This was accomplished by observing how military officers proceeded to find solutions to sample tactical problems. Participants were guided through interviews during which they described their thoughts while solving problems. They also identified thinking strategies that were useful to them.

The goal is to use information about the approaches and strategies of more experienced problem solvers to leverage training and instruction for the less skilled. In this way, potential error points can be countered.

Method

Participants

To address these questions, data were collected from 82 U.S. Army officers ranging in rank from 2nd Lieutenant ($n = 5$) and 1st Lieutenant ($n = 2$) to Lieutenant Colonel ($n = 3$). Most officers were Captains ($n = 51$) or Majors ($n = 21$). Time in service ranged from 1 to 19 years. Eighty officers participated in the interviews. Two participants contributed only partial data.

Materials

Four paragraph-length descriptions were written to represent the four types of approaches that one might adopt to solve a problem: the procedural approach (ST 101-5, 1994), the decision analytic approach (Anderson et al., 1981), the recognition-based approach (Klein, 1989), and the dominance approach (Montgomery, 1989). The descriptions are listed in the Appendix A.

Two problems were constructed. One problem placed the participant in the role of an mechanized infantry battalion commander whose mission was to cross a bridge held by friendly forces and establish a bridgehead in preparation for an offensive the following day. However, the "commander" receives new information and must decide on whether modifications are needed in the course of action. Most participants were expected to be familiar with this type of problem. The second problem placed the participant in the role of an infantry company commander. His company has been training in another

country when he is called into Battalion headquarters and assigned to rescue a U.S. ambassador and his family from their captors. Few participants were expected to be familiar with this type of problem.

Problems that were likely to be more and less familiar were used to allow participants to exercise their problem solving skills. Both problems included a deadline required by the mission. Problems were also characterized by prototypical tactical elements, such as mission, use of force, and presence of enemy elements. The problems differed in focus. The bridge problem was more typical for an infantry battalion, while the hostage situation was more unusual for a unit other than Ranger or Special Forces. The bridge problem was terrain-oriented while the hostage problem was rescue-oriented. It was expected that military leaders would have different levels of experience and knowledge about these two types of problems.

Sixty-six strategies were identified from various literatures. See Pounds and Fallesen (1994) for an elaborated listing. A subset of 48 were selected based on the criterion of minimizing redundant aspects of definitions. These were 29 information processing strategies and 19 choice strategies. A brief everyday definition of each strategy was put on individual 4x6 index cards so the participants' attention and discussion could be focused on individual strategies. For example, a decomposition strategy was represented by *Broke the problem into smaller problems.* The complete set of descriptions is listed in Appendix B.

Procedure

Participants were each scheduled for one three-hour interview, with approximately equal time allotted to discuss each of three problems. Each interview was recorded. First, the rationale and background for the study was discussed with each participant. Then each completed a demographic questionnaire.

Participants first discussed a problem that they had personally faced and solved. This served to "loosen up" the participants and to familiarize them with the procedure. Participants were assured that for each problem the researcher's primary interest was not in the correctness of the decision but in the thinking process that resulted in their solution.

Following each discussion, participants completed a card sorting task. Sixteen officers sorted into three categories (yes, no, uncertain). These were rescaled and included with the rest of the data. Sixty-four participants sorted the strategy cards into six categories: not used, uncertain, used (but not important), important, very important, and most important. Sorting was based on the participant's subjective judgment of how important the strategy was in solving the problem. Groupings were recorded.

Participants were then presented with the first of the two tactical problems and asked to talk aloud as they proceeded to "tell us what you would do" in the scenario. Order of problems was counterbalanced across participants. When the participant reached a solution, the card sorting task was again performed. The second tactical problem was then presented and the process repeated.

After completing the three problems and card sorting tasks, participants read the four descriptions of problem solving approaches and assigned 100% across the four descriptions to represent how each approach figured in their problem solving process. The only requirement was that the total percentage across all four descriptions summed to 100. This method allowed participants to indicate relative usage of approaches within the problem solving process without restricting their selection to one over the others. Any concerns or questions about the meaning of the descriptions were addressed by the

interviewer prior to final point assignment. If the participant thought that a fifth description was needed to describe his process, he assigned points to a fifth option. Thirty-two participants did this assignment only once for problem solving in general after they finished all three problems. Forty-eight participants did this rating before discussing the problems. Forty-six participants also made these assignments after each problem. All participants then listed any factors they thought influenced their use of one approach over another.

To identify other factors that might affect the tactical problem solving process, the first sample of participants ($n = 32$) was asked to identify other possible elements. The 108 responses reflected participants' concerns about the amount of time available to find a solution and plan a course of action, the importance of the mission, the type of problem and their familiarity with it, and the resources and constraints that were present. Based on these comments, two additions to the materials and procedures were incorporated for the last 48 participants. After solving *each* tactical problem, participants made a subjective judgment and distributed the 100% percentage points across the descriptions of the four approaches to show the percentage that each approach was used in the solution process for *that* problem. Participants also gave a subjective ratings on Likert scales to each of the following four questions asked after each problem. For each question, the scale was:

0...1...2...3...4...5...6...7...8...9...10
Very low Very high

(1) *How familiar are you with this type of problem/situation? In other words, how much experience or knowledge do you have with this type of situation?* Both experience and knowledge were incorporated into this question although some have suggested that these components are separable (Alba & Hutchison, 1987).

(2) *How important (or critical) is the outcome of the situation? In other words, how high are the stakes?* This question was intended to capture the importance that participants' attached to the consequences of their proposed actions.

(3) *How much time did you feel was available before you had to commit to a decision?* Both problems incorporated a time deadline for planning. Thus this question was intended to capture participants' perceptions of time pressure.

(4) *How much mental effort for thinking did it take to identify/resolve this problem?* This question required participants to estimate how much thinking they devoted to the process.

Results and Discussion

Eighty-two officers participated in the data collection. However, some had incomplete data because of unforeseen events, such as scheduling changes and unexpected duty requirements, which shortened their interviews. Also, some materials were incorporated into the interviews for only some subgroups as the project evolved. For example, the first 32 officers assigned points to their overall problem solving approach. The next 48 were also asked to give ratings for their approach to each problem in addition to their general approach. Thus, some of the analyses were conducted for these subgroups.

How Military Leaders Approach Problems

When asked how they generally preferred to approach problems, the 82 participants' distributed responses over all four approaches. These ratings were not made for any particular problem but for their generally preferred approach to solving whatever problems they face. Some participants made comments like: "In a perfect world, I would...."

Review of the percentages assigned to the four descriptions showed that most participants used more than one approach to solve problems. Some participants responded that they preferred not to use the analytic, procedural, recognition or dominance approaches in their problem solving processes at all. The range of results for each approach was:

Analytic	0 - 80 %
Procedural	0 - 100%
Recognition	0 - 80%
Dominance	0 - 60%

Examination of 95% confidence intervals around the mean number of points assigned to each approach (Gibbons, 1993) showed that participants reported using analytic and dominance approaches significantly less than either the procedural or recognition approach (Figure 1).

Three participants did not distribute the entire 100 points across the four presented approaches, preferring instead to also give points to a hypothetical, unnamed fifth approach that they posited might exist. For the general approach ratings, one participant gave the fifth category one point. For the Hostage problem, two participants rated a fifth category when responding to their approach. Those problem-specific responses were not included in the approaches to general problem solving shown (Figure 1 and Table 1).

Examples illustrate how participants elaborated the four approaches. One participant gave the analytic approach 30 points, procedural 40 points, recognition 20 points, and dominance 10 points when describing his general problem solving approach. However he noted two changes to the procedural approach's description.

> "Use screening and use the next best course of action instead of starting over. If time constrained then, reverse the order of these (he would reverse his ordering of point assignments)."

The one participant who assigned all 100% to a fifth category for his approach to the Hostage problem took parts of the other descriptions and added to them to make his own as follows. From the analytic approach he used nothing. He indicated that reconsideration (from the dominance approach description) and recognizing familiar situations (from the recognition approach description) were somewhat important. However, his main points were:

> "Clarify the situation and gather information without making judgments about it (from the procedural approach description). Consequences of using the usual solution are imagined to identify pitfalls (from the recognition approach description). Develop [a] best sub-optimal solution and work out details."

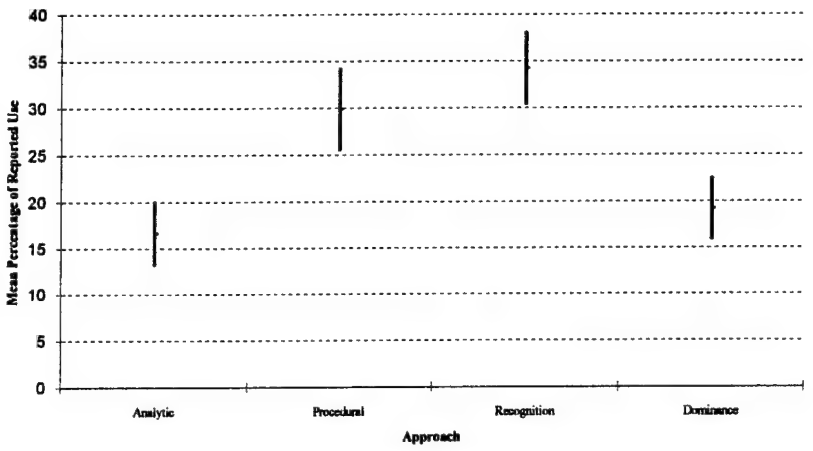

Figure 1
95% Confidence Interval Around the Mean for Each Approach (n = 82)

However, correlations between the percentages of reported use assigned to each approach showed that use of a recognition-based approach was negatively related to use of an analytic or a procedural method. Use of a dominance approach was also negatively related to use of both analytic and procedural approaches. Correlations (and probability values) are shown in Table 1. These relationships suggest that when people employ a detailed utility method or adopt a stepwise procedure, the two methods that emphasize development of a likely candidate were less likely to be rated as used. Approaches that give the problem solver a method to rely on may be employed when a likely solution is not immediately available. However, relying on procedure alone does not necessarily guarantee a good solution (e.g., if the quality of information used in the procedure is flawed or contradictions are not recognized).

Table 1
Correlations Between Approaches Based on Percent of Preferred Use (n = 82)

	Approach			
	Analytic	Procedural	Recognition	Dominance
Time in Service	.10 (.38)	-.10 (..37)	.05 (.65)	-.03 (.80)
Analytic		-.19 (.09)	-.40 (.0002)	-.32 (.004)
Procedural			-.55 (.0001)	-.49 (.0001)
Recognition				-.02 (.88)

U.S. Army doctrine and training advocates procedural/analytic approaches for problem solving and decision making. Thus, one could expect that participants' time in service (TIS) would be positively related to use of those approaches. Nevertheless, reported use of the four approaches was not correlated with participants' length of service. The relationships in Figure 1 support the idea that military leaders prefer to use a combination of approaches to find solutions. However, it is not clear when they call on different methods and what other approaches can be described beyond the four used for the present study.

Preliminary analyses to clarify how another approach might be described were conducted by Fallesen (1996). A cluster analysis performed on the strategy importance ratings from a subset of 32 participants suggested clusters of strategies based on different types of thinking processes: framing the problem, information quality, looking at the "big picture," comparison, objective evaluation, subjective evaluation, and reconsideration.

Influences on Approach Use

Because military leaders are more routinely exposed to problems of maneuvering forces while smaller numbers typically train for hostage rescue scenarios, it was hypothesized that the Bridge problem would be more familiar than the Hostage problem. Thus, participants would be more likely to adopt a recognition approach to solve the Bridge problem than the Hostage problem.

Other variables were also hypothesized to influence how participants approached the scenarios. Increased effort devoted to the problem solving task would be positively related to use of an analytic approach. Time available would be negatively related to use of a recognition approach. Payne et al. (1993) proposed that the importance of the decision leads to greater effort expended in making the decision. Thus, the importance of the outcome would be positively related to effort. However, the "decision about how to decide"--similar to what we are calling an "approach"-- is also contingent on a host of other task factors related to effort-accuracy trade-offs.

Forty-eight officers responded to the scaled questions for familiarity, effort, time, and stakes for both the Bridge and Hostage problem. Excluded were the post-training ratings for one of the tactical problems by officers who participated in a training session.

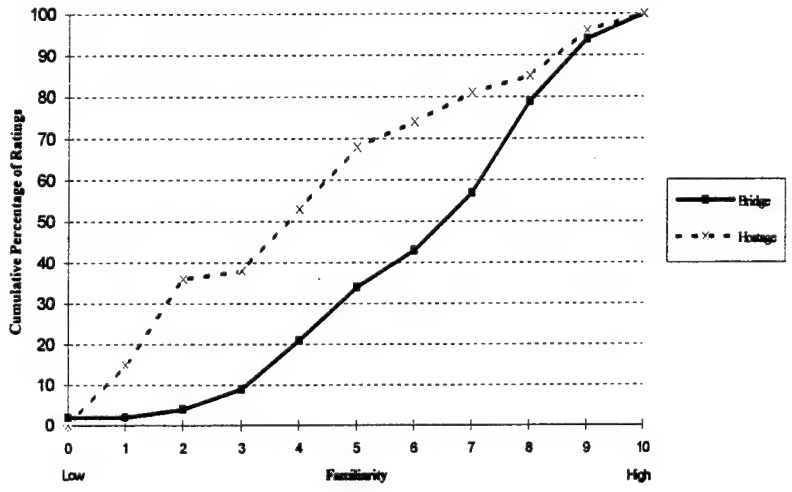

Figure 2
Distribution of Familiarity Ratings by Problem

As a manipulation check, familiarity ratings for the Bridge and Hostage problems were compared using analysis of variance. The Bridge scenario was rated significantly more familiar (M=6.75) than the Hostage scenario (M=4.42), $F(1, 61)=14.12$, $MSe=6.06$, $p<.0004$. Differences in responses to the problems are illustrated in Figure 2 as cumulative percentages.

Analyses of variance showed that the type of problem made a significant difference in participants' reported use of both a recognition approach, $F(1, 61)= 20.7$, $MSe=816.32$, $p<.0001$ and the dominance approach, $F(1, 61)= 5.91$, $MSe= 814.05$, $p<.018$. This supports the proposal that one's use of a dominance approach is also linked to using one's experiences (or lack of experience) in the problem domain. Problem type was not a significant effect on the reported use of either the analytic or the procedural approaches. Point distributions for each approach by problem are shown in Figure 3. Thus, the familiarity of the officer with the problem appears to be one factor that influences the approach which he or she adopts to find a solution.

Participants' ratings of familiarity with the problem were positively related to the use of a recognition approach (r =.50, $p<.0001$). Moreover, familiarity was negatively related to a dominance

approach (r =-.45, p<.0002). Familiarity with the problem was not significantly related to either an analytic or procedural approach. Instead of using a procedural approach for unfamiliar problems some participants used dominance, perhaps in the form of using a questioning strategy or sensitivity analysis (e.g., "What would happen if this option were dominant?" or "What would happen if this aspect was most important?"). Another possibility is that in the absence of domain specific experience to apply to the problem, the problem solver tried to transfer and apply knowledge from other domains.

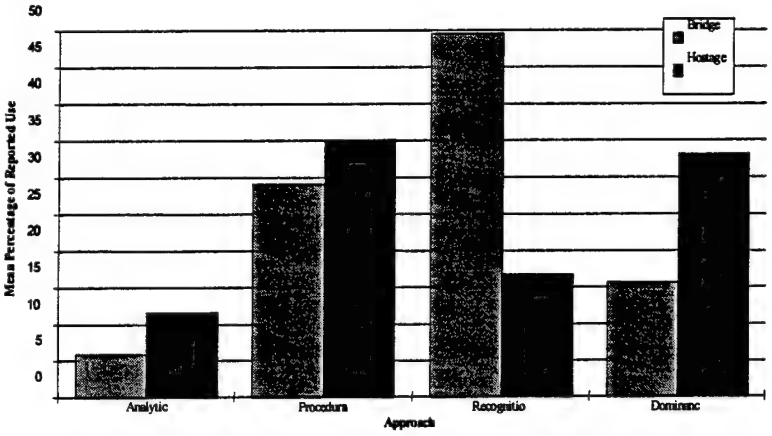

Figure 3
Use of Approach by Problem Type

This finding demonstrates that familiarity with the problem domain influences how one chooses to approach the problem. Although the relationship between familiarity, experience, and use of a recognition approach has also been demonstrated in other research (e.g., Klein et al., 1993) the relationship between familiarity, experience, and dominance is less clear. Something akin to familiarity or experience must be at work during the structuring processes of the dominance approach to enable the dominance process to develop a solution at all.

Based on findings from studies of schema-based reasoning and effort-accuracy trade-offs (Payne et al., 1993), it was hypothesized that use of an analytic approach would be positively related to participants' subjective effort ratings. This was the case. Use of the analytic approach was positively correlated with effort ratings (r =.28, p<.03). Moreover, effort ratings were negatively related to use of a recognition approach (r = -.30, p<.02).

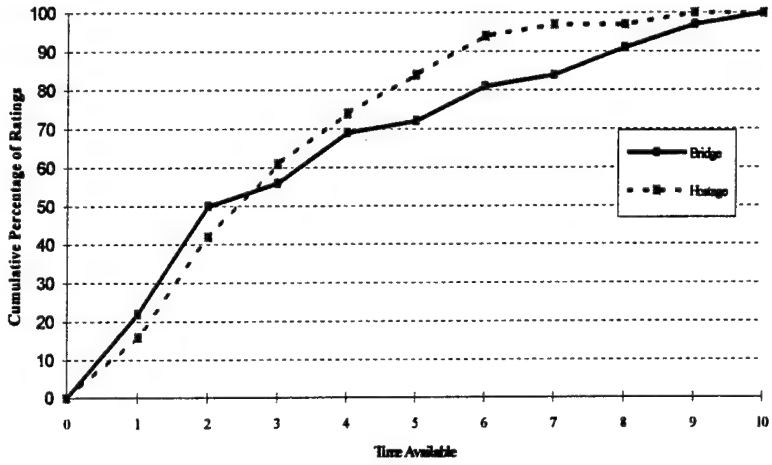

Figure 4
Ratings of Time Available by Problem

(4) Examination of responses to the *time available* question showed little variability across the two tactical scenarios. Most responses were toward the *Very Low* end of the scale for both problems (Figure 4). Participants' ratings of time available were not significantly related to any of the four approaches. Differences in responses to the question of available time are illustrated in Figure 4 as cumulative percentages.

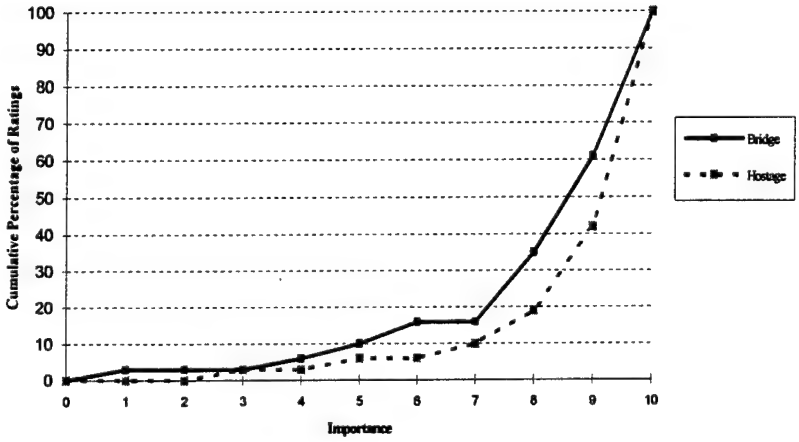

Figure 5
Ratings of Outcome Importance by Problem

(5) Examination of the responses to the *importance* question showed a lack of variability across the two tactical problems. Most participants responded with scale values toward the *Very High* end of the scale for both the Bridge and Hostage problems (Figure 5). The perceived criticality of the outcome was not significantly related to use of any of the approaches.

In sum, based on the analyses of the ratings of the approaches, it appears that whichever approach is adopted by the problem solver to find a solution depends on several factors. These results are in line with the findings of Fallesen (1993) by demonstrating that officers do not unilaterally adopt the "schoolhouse" procedural method when solving problems. The notion that people use a combination of approaches to reach a solution may be closer to reality. Moreover, other approaches might await description. If so, then future investigations should aim to identify other approaches, define them, and show how they work.

The type of problem that the officer confronts appears to be one factor that influences the approach which he or she adopts to find a solution. To explore that idea, the two scenarios used for the interviews were selected to represent a range of more and less familiar problem domains and constraints. However, it would be impossible to foresee every problem that military leaders might encounter on the battlefield, in garrison, and particularly during operations other than war. Thus, training would be

leveraged by an understanding of how military officers marshal their existing knowledge--whatever its level--to handle the uncertainty in situations where a rule cannot be applied. For example, rules or principles might be modified, or analogies made with remotely associated instances. Partial procedures from other instances might be combined.

The level of one's prior knowledge appears to play an important role in both recognition and dominance approaches. However, whether using the dominance approach compensates for lack of knowledge is not certain. Dominance processes may resemble hypothesis testing (e.g., "Is this course of action the one?"). Possibly, another approach shares some of the features of both dominance and recognition and can be described as the process of working with the less familiar to make it more familiar. If so, understanding how this process works could be used to enhance how one applies one's knowledge to problems.

Strategies Used

Tactical problem solving was also examined at the strategy level. In addition to enhancing the problem solver's overall approaches to problems, tactical problem solving can also be supported by examining which particular strategies are crafted together when solving a problem. Strategies have strengths which can be developed where they are lacking and weaknesses which can be addressed when they are present. Each strategy which is used would provide an opportunity for training and support. For example, those who are skilled in solving problems in their domain are better able to separate the important information from the irrelevant. Nevertheless, even skilled problem solvers' methods have been enhanced through training by pointing out how they were using meaningless information (Gaeth & Shanteau, 1984). Another example of how strategy use influences the problem solving process is the strategy of breaking the problem into smaller problems. This strategy works well to structure difficult or complex problems (Newell & Simon, 1972). However, this strategy is time consuming when the problem constraints or relevant aspects of the problem are not clear and it consumes most of the problem solving efforts leaving little for the actual solution process (Reitman, 1965; Voss & Post, 1988).

To determine the general types of strategies being used, data from the card sorting tasks following the tactical problems were used. Sorting for the individuals' own problem were excluded because recall of events was relatively more likely to be influenced by long-term memory retrieval processes, whereas the sorting for each tactical problem was done immediately after it was discussed. Moreover, the types of problems elicited from participants' experience varied widely. The individuals' recalled problems will be examined separately in future analyses. Card sorts were excluded for one problem from each of the 32 officers who participated in a training session related to one of the strategies.

To identify strategies that were generally used, means were calculated for all of the strategy phrases over both of the tactical problems. Forty-eight participants sorted cards for both tactical problems. Pretraining problems for another 32 participants were included. Strategies that participants rated as 3 ("Important") or higher are listed in Table 2.

Table 2
Strategy Importance Ratings Over Both Tactical Problems

	Strategy	Mean	SD
P18	Identified a specific goal	4.33	1.34
P21	Identified facts	3.79	1.32
C15	The best option had to meet certain required criteria	3.58	1.83
P9	Restated the problem by visualizing or drawing	3.48	1.45
P19	Identified problems in accomplishing the goals	3.37	1.38
P6	Considered what information was missing and its implications	3.24	1.63
P22	Identified assumptions	3.21	1.44
P12	Looked at the big picture before the details	3.11	1.72
P11	Broke the problem into smaller problems	3.04	1.67

Note. N = 128.

To identify differences in strategy use by problem, mean importance ratings were calculated for each strategy within each problem. Strategies that participants rated as 3 or higher for each problem are listed in Tables 3a and 3b. Hereafter, 'P' indicates a processing strategy. 'C' indicates a choice strategy. Two strategies were important in the Bridge problem (P12 and P27) but not in the Hostage problem. Three strategies (P11, P5, C16) were important in the Hostage problem but not in the Bridge problem.

Table 3a
Strategies Rated Greater Than or Equal to 3.00 for the Bridge Problem

	Strategy	Mean	SD
P18	Identified a specific goal	4.31	1.43
P21	Identified facts	3.75	1.29
P9	Restated the problem by visualizing or drawing	3.52	1.47
P12	Looked at the big picture before the details *	3.38	1.69
C15	The best option had to meet certain required criteria	3.35	1.94
P6	Considered what information was missing and its implications	3.30	1.45
P19	Identified problems in accomplishing the goals	3.20	1.44
P22	Identified assumptions	3.11	1.56
P27	Considered the accuracy of the information *	3.00	1.52

Note. * = non-overlapping between problems. N = 64.

Table 3b
Strategies Rated Greater Than or Equal to 3.00 for the Hostage Problem

	Strategy	Mean	SD
P18	Identified a specific goal	4.35	1.26
P21	Identified facts	3.83	1.36
C15	The best option had to meet certain required criteria	3.81	1.69
P19	Identified problems in accomplishing the goals	3.54	1.31
P9	Restated the problem by visualizing or drawing	3.44	1.44
P22	Identified assumptions	3.32	1.31
P11	Broke the problem into smaller problems *	3.23	1.60
P6	Considered what information was missing and its implications	3.19	1.81
P5	Determined parts of the plan that would be prone to flaws*	3.09	1.57
C16	The best option should have met certain desired criteria *	3.05	1.90

Note. * = non-overlapping between problems. N = 64.

Participants generally agreed (Table 2) that the two most important strategies for solving both problems were *Identified a specific goal* (P18) and *Identified facts* (P21). However, this does not mean that the goals and the facts were the same, only that the same strategies were used. The ratings did not reveal whether participants' goals were the same within problems or whether participants identified the same facts as relevant. The ratings suggest only that these strategic processes were similarly important. Only three strategies (P10, P26, and P12) differed by more than .5 rating points between problems. Comparisons of each strategy between problems showed no statistically significant difference in strategy ratings between problems.

A straightforward picture of strategy use would allow one to associate a unique set of strategies with each approach. However, if strategies are combined constructively, then it is reasonable to assume that some strategies are operating similarly in different approaches. It might not matter which strategies are used so long as a good solution is reached. The opposite might also be true: using strategies differently results in different solutions.

Strategy Use Related to Solution

To clarify whether differences in strategy use mattered, the data were examined to determine whether differential use of strategies would result in different solutions. Only solutions for the Bridge have been analyzed. Thus, the following discussions relating solutions to strategies were based on only responses to that problem. Fifty-seven solutions were used in the analysis.

For the present purposes, identification of an optimal solution was not necessary. In naturalistic settings, finding a satisfactory and feasible solution is the goal. Participants' solutions to the Bridge problem were summarized and sorted into groups based on the characteristics of participants' final proposed course of action. Two experimenters performed sorts and the discrepancies between groupings were resolved through discussion. The sorting process took the following form.

During the sorting process, several different possible conceptualizations for grouping solutions emerged. A nine-group sort was based on possible friendly forces' actions (e.g., defend, fix, attack, clear, seize, bypass) on possible objectives (e.g., current location, assembly area, bridge) as they moved over terrain. These basic groups were then regrouped by dimensions of the problem. Five groups were sorted based on collapsing over the nine groups on dimensions of movement forward (e.g., defend, attack,

bypass, assembly area, bridge). Six groups were sorted based on the primary focus of the solution (e.g., defend, bypass, assembly area, bridge, south of the river, north of the river). Four groups resulted from a sort based on possible perceptions of uncertainty in the situation (e.g., how uncertain or unclear was the information about the enemy, what level of risk was present in different courses of action, importance of assembly area to the original mission, did the mission change).

The groups resulting from each sort were evaluated by discriminant analysis using the importance ratings for all strategies as predictor variables. Discriminant procedures were employed as exploratory analyses (see Klecka, 1980; SAS Institute, 1988; Tabachnick & Fidell, 1989). Forward method stepwise discriminant analysis (p =.25 to enter the equations) was first used to identify a subset of strategies that entered the function for each solution grouping. For each grouping, the resulting strategies for the equation were then entered as the predictors in a discriminant analysis. The number of misclassified cases and the proportion of variation explained were used to compare solution groupings. The equation with the fewest misclassifications and which explained the most variation (Average Squared Canonical Correlation) was the function for the four-solution group, which was based on perceptions of the situation (see Table 4).

Table 4
Results of Discriminant Classifications for Each Grouping of Solutions

Solution Groups	Missed Cases	ASCC	Concept
9 groups	5	.59	friendly mission
5 groups	9	.63	forward movement
6 groups	4	.55	terrain focus
4 groups	0	.70	situation assessment

Maps illustrating each solution are shown in Figure 6. Definitions for the four solutions follow. The percent of total solutions in each group are given.

Solutions:

(1) Hold up and assume a defensive posture. The situation is uncertain. Establish positions on high ground. (5%)

(2) Attack and occupy the assembly area. This area is still the jumping off point for tomorrow's mission. (14%)

(3) Attack and clear through the assembly area and proceed to the river and take a position on the far side of the bridge. (58%)

(4) Fix the enemy in the assembly area and bypass, use an alternate assembly area, or forget any assembly area and focus on the bridge. (23%)

The four categories were based on taking into account the uncertainties in the evolving situation, confidence in the capacity to defeat the enemy, risk involved with continuing with the original mission orders or modifying them, and basing a solution on doing what one knows how to do rather than on the situation.

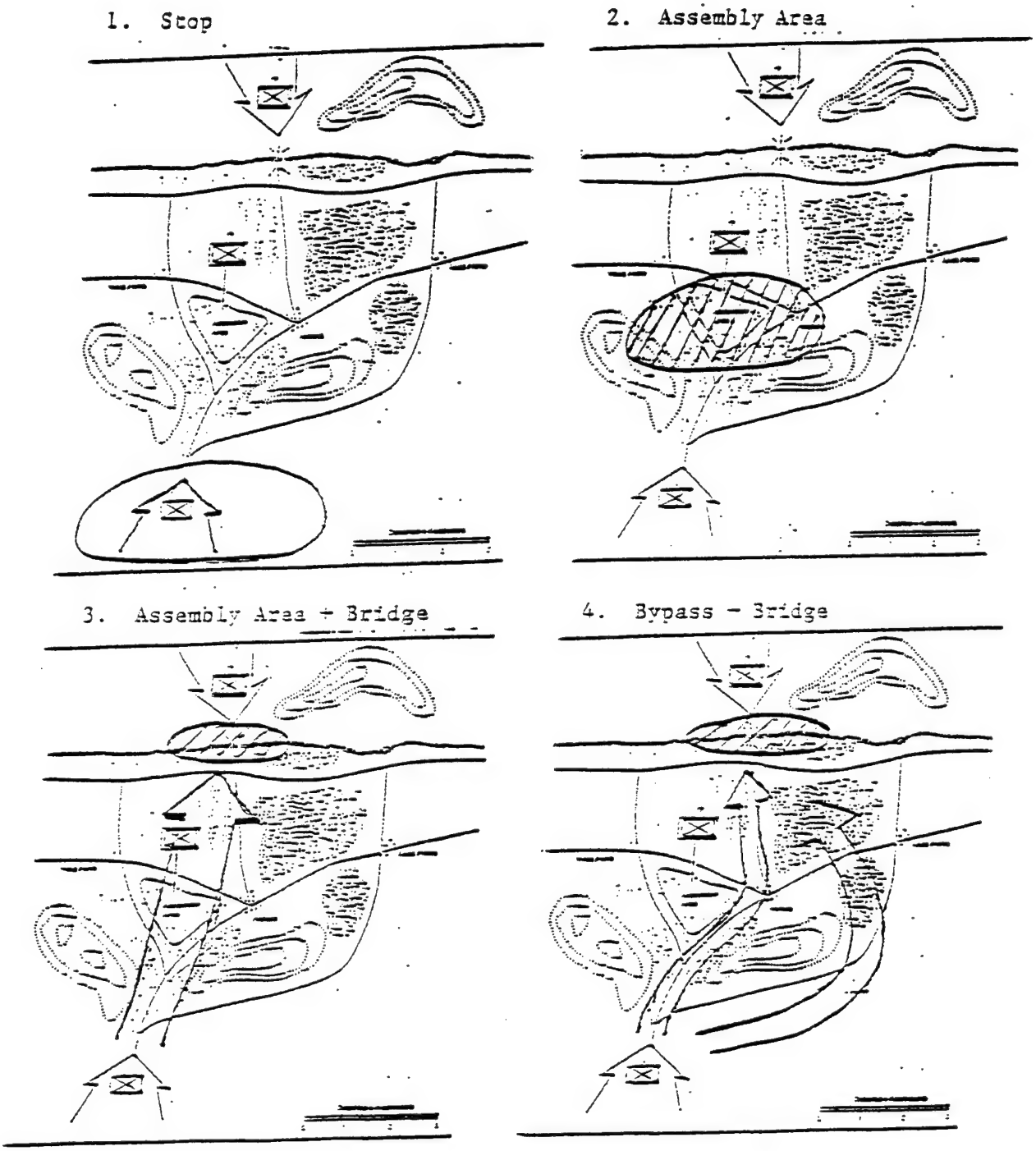

Figure 6

Maps of Solutions

The relationship between strategy use and solutions was examined to determine whether the reported use of a strategy was associated with a *particular* solution. Relationships between strategies and solutions could be important, particularly for instruction, if certain courses of action were more desirable on some characteristics than others. The four-group classification scheme for the solutions was used. Results showed how differential use of strategies was associated with different solutions.

The strategies that entered the equation during the stepwise discriminant analysis were entered as indicators in a discriminant analysis using the four solution groups as class variables. Table 5 shows the strategies and coefficients for each solution. In discriminant analysis the coefficients are estimated to result in the "best" separation between groups (Norusis/SPSS Inc., 1988). Interpretation of the coefficients is similar to that of multiple regression. Such interpretation must be made cautiously when indicators are correlated (Norusis/SPSS Inc., 1988). The informativeness and interpretation of the coefficient for a particular variable is relative to the other variables included in the classification function. Positive weights are highlighted for the 15 strategies that had a range of positive and negative weights across solutions. Seven strategies were positive indicators for all solutions. These are shown separately on the lower portion of the table.

Table 5
Classification Functions for Solutions by Strategies

	Strategy	Stop	AA	AA + Bridge	Bypass + Bridge
P26	Information reliability	-1.11	-1.52	.19	-.03
P5	Determined parts prone to flaws	-2.82	-1.86	.37	1.12
P11	Broke into smaller problems	-5.13	-2.92	.93	1.62
P20	Wrote down everything	-1.27	-.97	.95	1.80
P28	Considered information relevancy	-3.03	-1.11	1.43	1.98
P15	Imagined best outcomes	-3.83	.33	3.09	3.25
C17	Eliminate some options	-1.46	.60	2.92	2.64
C2	Option met own standards	-.13	1.11	.05	-.19
P23	Used specific and precise comparisons	1.68	3.71	2.54	-.05
P29	Suspended judgment	2.86	1.56	-.94	-.98
P2	Thought of differences with past experience	1.06	-1.07	-2.51	-1.52
C1	Small set of considerations	.61	-1.91	-1.52	-.51
C8	Qualitative comparisons	2.63	-.93	-2.42	-2.40
C12	Solution had worked most often in past	.20	-.52	-.70	.43
C6	Only large disadvantages	-2.14	-2.02	-.27	.99
	Positive indicators for all solutions				
P27	Information accuracy	5.55	8.29	4.72	2.38
P12	Big picture first	4.90	2.69	1.68	1.62
P22	Identified assumptions	3.63	4.57	3.04	1.77
P14	Kept set small	2.86	3.50	1.58	1.07
P7	Problem as story	2.78	2.96	.85	.50
C15	Best option had to meet required criteria	1.34	2.89	2.08	1.06
C19	Reexamined options	.65	3.21	3.14	2.40

Coefficients can be used to interpret differences between solutions. (Klecka, 1980). The sign and relative magnitude of the coefficient represent how the strategy's presence or absence was related to that particular solution. Just how these strategies relate to one's experience is not yet clear, although plausible hypotheses were suggested by the groupings. One explanation is that the "hold back" and the "bypass" solutions were both proposed by those participants who considered the larger, more uncertain aspects of the situation (e.g., What is the overall division situation? The enemy in the AA is not my problem. Do I

know enough about the unfolding situation?). On the other hand, those participants who became involved in attacking into or through the AA seemed to become involved in handling what they recognized as a standard situation involving contact with an enemy--one they had been trained for as part of a military career. Thus, immediately becoming immersed in maneuvering to thwart enemy operations characterized these groups (e.g., I will attack from each flank in a pincher movement. Are there enemy informants in the village? That is my designated area. I will lead with my tanks.) In other words, they solved the problem with what they knew, rather than considering whether it was the right problem to solve.

Pruning the Strategy Set

Rather than resulting in a smaller set of strategies, analyses of the data suggest several ways that knowledge about the strategies could be employed. For example, strategies that were positive indicators across all solutions (from Table 5) should be examined to find ways to make them more useful without increasing overall effort or time demands. Most of the strategies used for the sorting task have associated strengths and weaknesses. The frequency and magnitude of errors attributable to the weaknesses of the strategies being used can be determined.

Strategies that were positive and negative indicators for particular solutions need to be examined for their relationships with other strategies (from Table 5). For instance, people who *Imagined the best outcomes* (P15) did not appear to *Imagine the worst outcomes* (P16). At least, it did not enter the functions for the solutions. However, *Imagined parts of the plan that would be prone to flaws* (P5) was used by some. Those people proposed different solutions than did the people who did not use it.

Success using the "best outcome" method depends largely on domain knowledge and the ability to distinguish relevant from irrelevant information. It is an efficient and quick process. However, those who use it might also fail to search for counter-examples or fail to understand implications of the situation. Identifying these failure points to people who tend to naturally adopt a "best outcomes" strategy would probably enhance solution quality. To dwell only on success without considering the perils of the situation impacts contingency plans, an important component of planning.

Similarly, strategies such as (P28) *Identified relevant information* and (C12) *The solution that had worked most often in the past was chosen* merit examination. Results shown in Table 5 illustrate that the use of these strategies was associated with different proposed solutions

Strategies which were used infrequently but which have the potential for big improvements should also be included. Powerful strategies which were important to only a few people might have been obscured in group mean ratings of importance. For example, past studies have found that the ability to pick out diagnostic information and to use one's experience and knowledge to find solutions are hallmarks of skilled problem solvers (Abernathy & Hamm, 1995; Jacavone & Dostal, 1992).

Lines of Continuing Research

Generalizing findings from problems Findings from solutions to the Bridge problem will be compared with solutions for the Hostage scenario. This will elaborate understandings of the relationship of strategies and solutions relative to different types of problems. Some participants described the Bridge scenario as having more long-range consequences and unfolding into future problems, whereas the Hostage problem was a single event that would end when the friendly forces egressed the compound and returned the hostages to friendly territory.

Dealing with uncertainty Perception of uncertainties in a situation might influence strategy use. For example, some participants saw the uncertainty in the Bridge problem in determining the most important thing to do (e.g., clear out the enemy or take the bridge). On the other hand, for some participants the goal in the Hostage problem was clear: rescue the ambassador and his family. Other participants found the goal of the Hostage problem to be less clear. Was it to cause confusion in the minds of the captors, to keep the ambassador and the family from harm, to retain diplomatic sovereignty of which the ambassador was a symbol, or to send a message to other terrorists?

Strategies and approaches for dealing with uncertainty need further identification. People who have solved problems in uncertain situations might have developed efficient strategies that have gone unnoted, either because of the scarcity of this type of research or because the responses of a few individuals were unnoticed in group analyses.

Identify other influences Despite the effort to be comprehensive, it is possible that there are other influences on problem solving which were not captured by the set of strategies used for this study. Factors that might have important effects on problem solving, such as risk , personal values, and personal style, were not included in the present set. It might be that these types of variables have more significance in uncertain, ill-defined situations than supposed. Based on participants' comments from the transcripts, these factors should also be more specifically identified.

Instantiating strategies Understanding how strategies interact with individual differences, such as prior knowledge and experiences, would be useful. Participants' comments would be examined concurrently with the card sort information to determine whether the use of the same strategies lead to different solutions and, if so, why they did.

One possibility is that strategies interact with prior knowledge to generate instantiations of the current situation. For example, although two different participants rated *Identified a specific goal* as most important to their problem solving process, they may have identified different goals, which might result in different solutions. One participant who opted to take the assembly area said: "...you have to take these guys down so that you can accomplish your mission. So, I really have two missions but right [now] my specific goal is I have to get into that assembly area, I have to take down enemy forces in that area before I can go and do my next goal which is to cross the river at 0400." In contrast, a participant who chose to bypass the assembly area in favor of focusing on the bridge said: "...[t]he bridge was the objective in this case. Normally, the enemy is the objective and you want to destroy the enemy, but in this case, for the division to move through tomorrow, the bridge becomes more important...is the objective." Thus, although both participants said that they used the same strategy, the outcomes of their thinking processes (their solutions) were different due to content differences.

It may be that individual strategies, such as (C12) *Used the solution that had worked most often in the past*, can be leveraged when combined with strategies to select appropriate or relevant knowledge and information. Examination of participants' comments will be helpful in clarifying this relationship.

Verify metacognitive knowledge An assumption in this research and others was that, when prompted, participants can provide useful information by being aware of and reflecting on their own thinking. However, the limitations and problems of using interview data have been discussed elsewhere in detail (Ericsson & Simon, 1993; Rowe, 1985).

If card sorts do not faithfully represent participants' thinking processes or if participants were not able to fully translate their thinking processes to the cards' definitions, then findings from the card sorting

task can be supplemented by the transcripts from the interviews. When strategies are examined relative to content, it may be discovered that participants' card sort data lacked correspondence with the contents of their interviews. For example, a participant might have rated (P12) *Looked at the big picture before the details* as more important in his thinking than (P13) *Considered the details before the big picture*, but verbalized a focus on the details first in his conversation about the problem. If this was found to be the case, strategies could be assigned to include what they did instead of what they thought they did.

Training metacognitive knowledge and skill Many of the participants commented after the interviews that they enjoyed and were challenged by "thinking about what they were thinking." Some made comments like "I didn't use this strategy but maybe I should have." One participant noted that he hadn't really thought about the "big picture" and where friendly forces would be on his flanks as he attacked in zone. He realized that he had earlier made assumptions about the situation which might have been unwarranted and dangerous had he been in actual combat.

Comments such as these and the preliminary results of a training module (the results of which were not included in the present paper) related to one of the strategies suggest that instruction in thinking skills might be a fruitful avenue to pursue.

Conclusion

Approaching Problems

The analyses demonstrated that the participants adopted a variety of approaches to solve problems rather than adhering to one method. Participants' ratings of their approaches support the notion that combinations of approaches were used. Thus, current "schoolhouse" emphasis on procedural and analytic methods neglects other approaches that are reportedly being used on the job. This observation was supported by several participants' comments to the effect that "We were taught it in the course, but we go home and we don't use it much." The strengths and weaknesses of these and other approaches should be pointed out, explained, and supported.

Problem Strategies

Examining how strategies were used and how they were combined illustrated that differential use of strategies was associated with different proposed solutions. By making problem solvers aware of the strategies that they *do* use and the points where the strategies are fallible, natural tendencies could be enhanced and potential for large errors diminished. The results of these analyses provide evidence for selecting strategies for further examination with the intention of enhancement and support.

Future Directions

One approach to improving problem solving in complex and dynamic problem situations would be to increase knowledge about the various problem situations that one might encounter. The problem with this perspective is that dynamic and ill-defined problems are novel cases by nature. It would be impossible to predict all of the relevant attributes and contingencies to be captured and trained for a set of all possible future situations. Therefore, since all knowledge and information can't be known at any point in time and all possible cases can't be identified, a different plan would be to focus on methods to increase problem solvers' abilities to leverage their knowledge and situational information to meet the demands of particular circumstances in which they find themselves.

Thus, one potential way to increase flexible problem solving ability might be through raising awareness about the strategies that one uses and about other strategies that could potentially be useful. However, situations for training these types of metacognitive skills should be chosen carefully. The ultimate purpose of elaborating one's set of strategies is so that they can be used in time-constrained situations with little effort. Therefore, the effortful processing about the strategies, which might initially degrade performance during practice, should be enabled *before* one needs to use them, much like the proactive preplanning work done by effective flight crews (Wickens, 1996).

Benefits

Understandings about how problem solvers actually solve problems could enhance training by identifying ways that successful problem solvers respond to situations. These techniques could be demonstrated to the less experienced.

Training time could be exploited to amplify existing strengths rather than to enforce unnatural methods. For example, one participant said that he used solutions that had worked most often in the past, always spliting teams in half when attacking buildings. Based on his past negative experiences when fire support had been missing, he believed that forces clearing buildings should always have covering and suppressing fire support. He relied on his knowledge about similar situations to plan his course of action: "If it worked in the past there is no reason why it won't work again in the same situation or similar situations." He did not pause in his problem solving process to decide whether to have supporting fire and how much. He relied on a strategy using frequency of past experiences and matching processes to match one's knowledge with the current situation. However, effective use of this strategy depends on finding a good match between experiences and the current situation. Thus, how the problem solver defines the problem and identifies relevant information influences the success of this strategy.

Recommendations

A basis for instruction and training can be established by understanding how successful problem solvers differ from the less experienced in the ways that they go about solving problems. Including analysis of the strategies and solutions to the Hostage problem to those of the Bridge problem would broaden the findings to multiple scenarios. Examining similarities within subgroups of participants would uncover whether efficient or new strategies went unnoted because they were only used by a few people. Strategies and approaches that may be efficient and have been unnoted should be catalogued. Understandings of other individual variables that influence problem solving, such as personal values and reactions to uncertainty should be developed. Ongoing research findings and issues should be communicated to practitioners so that they can begin to capitalize on the strengths of naturally occurring problem solving approaches and strategies.

References

Abernathy, C. M., & Hamm, R. M. (1995). *Surgical intuition. What it is and how to get it.* Philadelphia, PA: Hanley & Belfus, Inc.

Alba, J. W., & Hutchinson, J. W. (1987). Dimensions of consumer expertise. *Journal of Consumer Research, 13*, 411-454.

Anderson, B. F., Deane, D. H., Hammond, K. R., & McClelland, G. H. (1981). *Concepts in judgement and decision research*. New York, NY: Praeger.

Beach, L. R. (1990). *Image theory: Decision making in personal and organizational contexts*. Chichester, UK: Wiley.

Beach, L. R., & Lipshitz, R. (1993). Why Classical Decision Theory is an inappropriate standard for evaluating and aiding most human decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 21-35). Norwood, NJ: Ablex.

Bransford, J. D., & Stein, B. S. (1993). *The ideal problem solver*. New York: W. H. Freeman.

Bruner, J. S., Goodnow, J. J. & Austin, G. A. (1956). *A study of thinking*. New York, NY: John Wiley & Sons, Inc.

Catrambone, R. (1995). *Predicting what people learn from examples* (Technical Report No. N00014-91-J-1137 G). Arlington, VA: Office of Naval Research.

Connolly, T., & Wagner, W. G. (1988). Decision cycles. In R. L. Cardy, S. M. Puffer, & M. M. Newman (Eds.), *Advances in information processing in organizations* (Vol. 3, pp. 183-205). Greenwich, CT: JAI Press.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis (revised ed.)*. Cambridge, MA: MIT Press.

Fallesen, J. J. (1993). *Overview of Army tactical planning performance research* (Technical Report No. 984). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A273 273)

Fallesen, J. J. (1996, May). Understanding and improving tactical problem solving. *Principal Scientist Colloquium*, (ARI Special Report 26, pp. 33-49). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Fallesen, J. J., Carter, C. F. Jr., Perkins, M. S., Michel, R. R., Flanagan, J. P., & McKeown, P. E. (1992). *The effects of procedural structure and computer support upon selecting a tactical course of action* (ARI Technical Report No. 960). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A257 254)

Fallesen, J. J., Michel, R. R., Lussier, J. W., & Pounds, J. (1996). *Practical thinking: Innovation in Battle Command instruction* (ARI Technical Report No. 1037). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ford, J. K., Schmitt, N., Schechtman, S. L., Hults, B. M., & Doherty, M. L. (1989). Process tracing methods: Contributions, problems, and neglected research questions. *Organizational Behavior and Human Decision Processes, 43*, 75-117.

Gaeth, G. J., & Shanteau, J. (1984). Reducing the influence of irrelevant information on experienced decision makers. *Organizational Behavior and Human Performance, 33*, 263-282.

Getzels, J. W., & Csikszentmihalyi, M. (1976). *The creative vision: A longitudinal study of problem finding in art*. New York: John Wiley & Sons.

Gibbons, J. D. (1993). Nonparametric statistics. Newbury Park, CA: Sage.

Halpin, S. M. (1995, May-June). Developing Force XXI battle commanders. *Army RD&A*, 7-9.

Hammond, K. R. (1993). Naturalistic decision making from a Brunswikian viewpoint: Its past, present, future. In Klein, Orasanu, Calderwood, & Zsambok (Eds.), *Decision making in action: Models and methods* (pp.205-227). Norwood, NJ: Ablex.

Jacavone, J., & Dostal, M. (1992). A descriptive study of nursing judgment in the assessment and management of cardiac pain. *Advances in Nursing Science, 15*(1), 54-63.

Janis, I. L., & Mann, L. (1977). *Decision making*. New York: The Free Press.

Klecka, W. R. (1980). *Discriminant analysis*. Newbury Park, CA: Sage Publishing.

Klein, G. A. (1989, May). Strategies of decision making. *Military Review*, 56-64.

Klein, G. A. (1993). A recognition-primed decision (RPD) model of rapid decision making. In Klein, Orasanu, Calderwood, & Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 138-147). Norwood, NJ: Ablex.

Klein, G. A., Calderwood, R., & Clinton-Cirrocco, A. (1986). Rapid decision making on the fire ground. *Proceedings of the Human Factors Society 30th Annual Meeting, 1*, 576-580.

Klein, G. A., Orasanu, J., Calderwood, R., & Zsambok, C. E. (1993). *Decision making in action: Models and methods*. Norwood, NJ: Ablex.

Lipshitz, R. (1993). Decision making as argument-driven action. In Klein, Orasanu, Calderwood, & Zsambok (Eds.), *Decision making in action: Models and methods* (172-181). Norwood, NJ: Ablex.

Miller, G. A., Galanter, E., & Pribram, K. H. (1960). *Plans and the structure of behavior*. New York: Holt.

Montgomery, H. (1989). From cognition to action: The search for dominance in decision making. In H. Montgomery & O. Svenson (Eds.), *Process and structure in human decision making* (pp. 23-49). New York: John Wiley & Sons.

Newell, A., & Simon, H. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Norušis/SPSS Inc. (1988). *SPSS^{x} advanced statistics guide (2nd ed.)*. Chicago, Il: SPSS International.

Orasanu, J., & Connolly, T. (1993). The reinvention of decision making. In Klein, Orasanu, Calderwood, & Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 3-20). Norwood, NJ: Ablex.

Payne, J. W., Bettman, J. R., Johnson, E. J. (1993). The use of multiple strategies in judgment and choice. In N. J. Castellan, Jr. (Ed.), *Individual and group decision making* (pp. 19-39), Hillsdale, NJ: Lawrence Erlbaum.

Pounds, J. F., & Fallesen, J. J. (1994). *Understanding problem solving strategies* (ARI Technical Report No. 1020). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A290 350)

Reitman, W. (1965). *Cognition and thought*. New York: Wiley.

Rowe, H. A. H. (1985). *Problem solving and intelligence*. Hillsdale, NJ: Lawrence Erlbaum.

Rumsey, M. G. (1995, May-June). Soldier selection for Force XXI. *Army RD&A*, 5-6.

SAS Institute Inc. (1988). *SAS/STAT™ User's guide* (6.03 ed.). Cary, NC: SAS Institute Inc.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics, 69*, 99-118.

Tabachnick, B. G., & Fidell, L. S. (1989). *Using multivariate statistics* (2nd ed.). New York: Harper Collins.

U.S. Army Command and General Staff College (CGSC). (1994). *Student Text (ST) 101-5, Command and Staff Decision Processes*. Fort Leavenworth, KS: Author.

Voss, J. F., & Post., T. A. (1988). On the solving of ill-structured problems. In M. T. H. Chi, R. Glaser, & M. J. Farr (Eds.), *The nature of expertise*. Hillsdale, NJ: Lawrence Erlbaum.

Wickens, C. D. (1996). Designing for stress. In J. E. Driskell & E. Salas (Eds.), *Stress and human performance* (pp. 279-295). Mahwah, NJ: Lawrence Erlbaum.

Appendix A

Definitions of Approaches

Participants assigned points to the following four definitions when identifying their general and problem-specific approaches. The definitions were read without identifying labels.

Analytic: Always generate options systematically, identify criteria for evaluating these options, assign weights to the evaluation criteria, rate each option on each criterion and tabulate the scores to find the best option. Use probability and utility to evaluate alternatives and to calculate possible outcomes. The alternative with the highest outcome is selected.

Procedural: Clarify the situation and gather information without making judgments about it. Identify several alternative solutions. Do a complete analysis of the merit of each alternative before comparing them to one another. Select the best alternative based on the results of the analysis. Implement the solution If the chosen alternative does not work, begin the process of selecting alternatives again.

Recognition: The problem is recognized as familiar. If the situation is very familiar, then a familiar solution may be recognized. Consequences of using the usual solution are imagined to identify pitfalls. If unworkable, then an alternative is developed based on what goals are feasible, what information is important, what to expect next, and what actions are typical in this situation.

Dominance: A promising alternative is identified and the others that have no chance of becoming the best overall are discarded. Determine whether the promising alternative has any disadvantage compared to other alternatives or to some other criterion. If it doesn't have any disadvantages it is chosen. If it does, then information about the alternative's advantages and disadvantages is reconsidered. Upon reconsideration, that alternative is discarded and the process repeated.

Appendix B

List of Strategies

Processing Strategies

Thought of similarities between the information in this problem and what was already known from past experience.

Thought of differences between the information in this problem and what was already known from past experience.

Deconflict information.

Thought in terms of *if-then* thoughts. For example, *if* the weather is bad *then* an alternate route is needed.

Determined parts of the plan that would be prone to flaws.

Considered what information was missing and its implications.

Looked at the problem in terms of a story to develop a fuller understanding.

Considered the solution in terms of a story to develop a fuller understanding.

Restated the problem by visualizing or drawing.

Restated the problem in different terms by looking at it as a different type of problem. For example, an offensive problem was relooked as a defensive problem.

Broke the problem into smaller problems.

Looked at the big picture before the details.

Considered details before the big picture.

Kept the set of things to think about as small as possible.

Imagined the best outcomes.

Imagined the worst outcomes.

Spent time considering various perspectives on the situation.

Identified a specific goal.

Identified problems in accomplishing the goals.

Wrote down everything that I knew about the problem.

Identified facts.

Identified assumptions.

Used specific and precise comparisons.

Used general and approximate comparisons.

Identified information that was unusual.

Considered the reliability of information.

Considered the accuracy of information.

Considered the relevancy of information.

Suspended judgment about possible alternatives until all the information was examined.

Choice Strategies

The best option had to meet certain required criteria.

The best option should have met certain desired criteria.

Some options were eliminated before comparing options.

More than one option was found to be acceptable.

Acceptable options were reexamined to see if one had more important characteristics than another.

An option was selected if it met my own internal standards.

An option was selected if it met standards specified by others.

Chose the option that had at least one important characteristic.

Chose the option that was better than all the others on one important characteristic.

An option's disadvantage was considered important only when it was a large disadvantage.

Trade-offs were made between an option's advantages and disadvantages.

Options were judged qualitatively, for example, good, bad, acceptable, etc.

Options were evaluated using quantitative (numerical) assessments.

Used a screening technique to select options for further consideration.

The option that had occurred most often in the past was chosen.

The solution that had worked most often in the past was chosen.

The option that was most attractive on the most important characteristic was chosen.

If the proposed solution was acceptable, no other solutions were considered.

Kept the set of things to think about as small as possible. (This strategy was intentionally used in both sets.)